Fully automated voxel repositioning in longitudinal ^{1}H MRS

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Introduction

Voxel repositioning in proton magnetic resonance spectroscopy (MRS) is a source of variability in longitutidinal studies (see Figure 1). Effects of repositioning have been studied using careful manual repositioning [1], and landmark registration [2]. We present a study of the effects of voxel repositioning in short echo PRESS MRS in normal healthy volunteers. An automatic image registration algorithm based on [3] has been developed and interfaced with a 3T scanner (GE Healthcare, Milwaukee, WI), registering the subject's anatomy during a follow-up exam to a previous (baseline) exam. The system performs registration of a localizer image and uses the output transform to give the location of the MRS voxel in the follow-up exam corresponding to the location in the baseline exam.

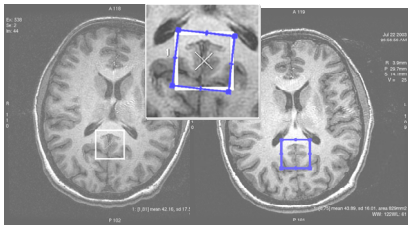

Figure 1: *Manual repositioning error. Translational error was out of plane, while rotation error was both in- and out- of plane.*

Methods

Using the Insight Toolkit [5], an image registration algorithm was developed based on the Mattes [3] formulation of the mutual information equation. Algorithms of this class may be used to register images with different contrast properties, *e.g.* T1 and T2, and generally converge rapidly with approximately 1*mm* accuracy [4]. The system reads DICOM images of the baseline localizer scan, baseline MRS scan, and follow-up localizer scan. After registration, 3 translations and 3 rotations are input to a custom pulse sequence allowing reacquisition of the follow-up localizer scan in the same position and orientation as the baseline scan, accommodating both changes in position and rotation (see Figure **2**). The calculated RAS location of the follow-up voxel is prescribed for the follow-up MRS. The acquisition protocol consists of an IR-prepped 3D SPGR axial localizer scan (TE 4.1*ms*, TR 9.9*ms*, TI 300*ms*), and a PRESS MRS sequence (TE 35*ms*, TR 2*s*) acquiring an 8*cc* voxel in the region of the posterior cingulate gyrus. In each follow-up exam, a manually placed MRS voxel was acquired in addition to the automatically repositioned MRS voxel; the MRS acquisition order was randomized. Follow-up voxel overlap and displacement were calculated for all MRS acquisitions. Exams were performed on 4 normal healthy volunteers over 4 scanning sessions on different days. Each scanning session consisted of 3 exams with approximately 1 hour between exams. Each volunteer had 12 manually placed MRS scans and 12 automatically placed MRS scans. Coefficients of variation (CV) for creatine(Cr), glutamate(Glu), myo-Inositol(mI), choline(Cho), N-acetylaspartate(NAA), Glu/Cr, mI/Cr, Cho/Cr and NAA/Cr were computed for each volunteer on a per session basis and averaged; in this way normal metabolic changes are controlled leaving only system variation and effects of voxel repositioning.

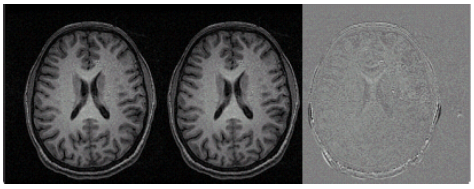

Figure 2: *Baseline, registered triple oblique followup and difference image showing registration accuracy.*

Results and Discussion

The 4 volunteers were imaged on a 3T scanner (GE Healthcare, Milwaukee WI) after giving proper informed consent. Resulting voxel overlap, and voxel displacement for each volunteer are shown in Table 1. Average intra-day, intra-volunteer CVs for each metabolite are shown in Table 2. Using automated repositioning, displacement errors decreased 68% from an average of 1.85*mm* to 0.79*mm*, while voxel overlap increased by 8% from 86% to 94%. Inexact table placement and subject motion contribute to the displacement error. CVs for Cr, Glu, mI, NAA, Glu/Cr, mI/Cr, and Cho/Cr improved while Cho and NAA/Cr showed a slight decline. Cr, Glu and Cho/Cr showed > 10% improvement. In addition to enhancing workflow, automated MRS voxel placement decreased the average intra-day CV for 7 of 9 metabolites.

References

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2. Hartmann, *et. al.*, CMI&G 1998 22(6): 453.
3. Mattes, *et. al.*, IEEE TMI. 2003 22(1):120.
4. West, *et. al.*, JCAT. 1997 21(4):554.
5. Yoo, *et. al.*, Proc. of Medicine Meets Virtual Reality 2002, pp586.

Volunteer	1	2	3	4	Average	Avg. Displacement
Manual Overlap (%)	84	86	87	89	86%	1.85*mm*
Automatic Overlap (%)	94	94	94	94	94%	0.79*mm*

Table 1: MRS Voxel overlap and displacement.

	Cr	Glu	Glu/Cr	mI	mI/Cr	Cho	Cho/Cr	NAA	NAA/Cr
Manual	3.84	7.40	6.96	6.18	5.7	4.53	5.33	4.32	3.65
Automatic	2.76	6.23	6.89	6.01	5.15	4.82	4.73	4.22	4.12

Table 2: Intra-session average CV for manual and automatic MRS voxel placement. Underline indicates a > 10% improvement in automatic placement.